MECHANICAL METHODS OF STEEL PLACEMENT FOR THE SLIPFORM CONSTRUCTION OF CONTINUOUSLY REINFORCED CONCRETE PAVEMENTS

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BY

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JHRP

JOINT HIGHWAY RESEARCH PROJECT

PURDUE UNIVERSITY AND

INDIANA STATE HIGHWAY COMMISSION

Technical Paper

MECHANICAL METHODS OF STEEL PLACEMENT FOR THE SLIPFORM CONSTRUCTION OF CONTINUOUSLY REINFORCED CONCRETE PAVEMENTS

TO: J. F. McLaughlin, Director
Joint Highway Research Project

December 28, 1971

Project: C-36-67E

FROM: H. L. Michael, Associate Director
Joint Highway Research Project

File: 9-11-5

The attached Technical Paper "Mechanical Methods of Steel Placement for the Slipform Construction of Continuously Reinforced Concrete Pavements" will be presented to the 1972 Annual Meeting of the Highway Research Board in January 1972. It has been authored by Professor C. F. Scholer and Mr. O. T. Olateju of our staff. The paper is also scheduled for publication by the Highway Research Board.

The paper summarizes some of the material contained in the Final Report on the J.H.R.P. research project "Techniques in Slipform Paving and Continuously Reinforced Concrete Pavement Construction" by O. T. Olateju under the direction of Professor J. A. Havers of our staff.

The paper is presented for information and for approval of publication.

Respectfully submitted,

Harold L. Michael
Associate Director

HLM/lm

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MECHANICAL METHODS OF STEEL PLACEMENT FOR THE SLIPFORM CONSTRUCTION OF CONTINUOUSLY REINFORCED CONCRETE PAVEMENTS

by

C. F. Scholer[1] and O. T. Olateju[2]

BACKGROUND

The information contained in this paper has been extracted from a March, 1971 report entitled, "Techniques in Slipform Paving and Continuously Reinforced Concrete Pavement Construction". This source document is identified as Joint Highway Research Project Report No. 6, 1971, and is available through the School of Civil Engineering at Purdue University. The study was performed by Mr. Olubayo T. Olateju, under the direction of Dr. John A. Havers.

The purpose of the Research was to examine current highway construction techniques which would reduce pavement costs without sacrificing pavement quality. It was believed that an investigation into the presently used methods for slipform paving and for installing reinforcing steel for continuously reinforced concrete pavement (CRCP) would help in satisfying the stated objective.

During the conduct of the research, several contractors, state highway officials, equipment manufacturers, private individuals, and private companies who have been actively involved in the areas of slipform paving and CRCP were contacted. These contacts were made to gain information about the operations of slipform pavers and several devices

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for installing reinforcing steel, and to determine the potential and realized construction cost savings associated with the use of these techniques.

The first part of the four part final report included a review of the development, acceptance and usage of the slipform paving technique. Highlighted in this part were those features of slipform paving technique which are essential in achieving smooth and durable concrete pavements. Such features included subbase and subgrade preparation, production and control of concrete, delivery of concrete to the paver, and formation of the slab. Other features included were seven different methods for checking the smoothness of the pavement surface, and three practical and three prospective non-destructive methods for checking pavement slab thickness. Also included in the first part was a discussion of the use of slipform paving technique in paving non-standard pavement sections such as ramps, super-elevations, sidewalks, median strips, curbs, etc. This part of the report was concluded with a look into the future of slipform paving in the light of the present field problems, new markets, and new ideas.

The second part deals exclusively with the methods presently available for installing reinforcing steel for CRCP construction. This paper deals only with this part of the report.

The third part involved actual field observation of construction operations involving the use of slipformers and each of the several methods for installing reinforcing steel for CRCP construction which were identified in the second part of the report. Observations were

made on eight different jobs which were located in the states of Indiana, Illinois, Minnesota, Iowa and North Dakota. Each field observation was recorded on time lapse movies which were later critically analyzed for the procedure and labor distribution involved with the steel placing operation. Each analysis was followed by comments on the weaknesses associated with some of the operations, where such weaknesses exist, and how the contractor could remedy them.

The fourth and final part discussed the research findings. These findings included reported construction cost savings realized from the use of the modern construction techniques, problems associated with the use of slipformers, field construction problems, and many others. This was followed by conclusions and recommendations.

As stated earlier, however, the presentation tonight will deal essentially with the second part of the research namely, methods of installing reinforcing steel for CRCP construction.

INTRODUCTION

Traditional methods for the incorporation of steel in concrete pavement slabs have included the use of chair supports, "two-lift" placement with the reinforcement sandwiched between two layers of concrete, and movable sled-type devices which were used to hold the steel at predetermined heights and are rolled away as the concrete is poured. The rate at which steel could be placed by any of these methods was not compatible with the inherent production capabilities of the slipform paver. Consequently, during the last several years, major efforts have been directed towards the development of mechanical methods for placing mesh and/or reinforcing bars in conjunction with

slipform paving. Today, thanks to these improved devices, contractors can lay 6000 ft or more of reinforcement in less than ten hours.

The mechanical devices for steel placement in pavement slabs can be categorized into two general groups. The first of these contains the mesh depressors, and the second consists of bar placers.

MESH DEPRESSORS

The mesh depressor was the first breakthrough in the contractors' search for machines to place reinforcement in one lift. It was used in Oregon in 1960, in Louisiana in 1961, and in Indiana in 1962. The early version of this unit rode on forms and used vibration and pressure to depress the steel. The unit depressed the steel while standing stationary, which precluded the lateral displacement of the mesh during depression. The machine was self-propelled and carried four hydraulic rams under which was suspended a lattice steel frame. On the frame at each ram was a vibrator. Limit chains were used to halt the frame at the correct depth for mesh imbedment. The rams then retracted the frame in preparation for the next sinking cycle. Another version, used in Indiana in 1962, consisted of a giant screen or grid which vibrated and depressed the sheet of mesh fabric to its proper depth. The steel placement unit was fitted with large depressing units which left a "waffle" pattern on the concrete. Its pressing depth was governed by adjustable lock-nuts on threaded guide rods instead of by limit chains.

As of the time of this study, the manufacturers of mechanical mesh depressors are Heltzel Steel Form Co., Rex Chainbelt Co., and CMI, Inc. Each of these companies produces a single model which can be used either with sideform or with slipform paving. The machine made by the Heltzel Company is a self-propelled unit, while the other two are attachments to slipform pavers, spreaders, or finishers. (See Fig. 1)

The Heltzel Co. unit is adjustable in width from 12 to 24 feet, and carries four grids with vibration runners on 20 x 23 in centers. Each grid consists of four blades welded to the vibrator housing. The basic length of the grid is 10 ft. with detachable end sections providing for a total length of 15 ft. The machine depresses steel from the surface of the full depth slab. Mesh is placed on the surface of the wet slab and the machine moves forward to position directly over the mesh. As the mesh depressor comes to a full stop, its operator actuates the vibration grids and the hydraulic pressure. Vibration and pressure are the major factors responsible for sinking the *mesh* . Vibration causes the movement of the wire down into the mix by helping the aggregate particles to move slightly aside. After the mesh has been depressed to the proper depth, hydraulic cylinders lift the grids from the concrete and the machine moves to the next position. The operation of depressing the steel takes between 10 and 18 seconds, and leaves a waffle pattern on the slab. Although the machine stands squarely on the mesh which is being depressed, a length of one foot or more of the next mesh section at the point of overlap is also depressed. This eliminates the possibility of the next sheet being dragged as the machine

moves forward. It also eliminates the need for more extensive vibration of the concrete after the initial depression cycle.

The current model of the Rex Chainbelt unit was introduced in 1965. This unit rides on crawler tracks as an attachment to the front of a placer or slipform paver. It consists essentially of a set of blades, in two banks, which is attached to a frame. A mechanism of gears and springs within this frame produces an eccentric movement with an amplitude of 3/4 inch. This arrangement imparts an oscillatory motion to the blades, and the resulting tamping and tucking action makes continuous steel placement possible without vibration. The final depth for the steel depends on the setting of the rear ends of the blades. Both the blades and the slopes can be adjusted for the paving conditions encountered. The depressor blades are evenly spaced across the full slab width and can depress mesh to depths of 6 inches. The depressor units are hydraulically lifted to pass over dowel brackets, and crown adjustments are made from the slipform or placer console. (See Fig. 2)

The unit manufactured by CMI, Inc. also attaches to the front of a slipform paver. It depresses the mesh into the mix by using high frequency vibration and low amplitude. The blades are vibrated at 2000 to 4000 cpm with an amplitude of 1/8 inch. Vertical baffles are responsible for pushing the steel into the concrete. The machine rides on pneumatic tires and is hydraulically powered from the slipform unit. It is equipped with sideforms to keep the mix within the paving boundaries while the steel is being depressed. (See Fig. 3)

BAR PLACERS

With bar mats and mesh, most of the labor is performed in the shop and relatively few men are required in the field. With reinforcing bars, however, men are required to load and unload the steel, distribute, and tie it. Contractors have therefore developed machines which help to speed the lapping and tieing. They have also developed machines which, once the steel has been tied, will hold it in the desired position for pavement construction. This position can either be the final one, in which case the concrete is placed through and around steel, or the steel can be placed on the surface of the fresh concrete and then depressed to its final position. Three distinct types of equipment can be identified within the bar placer group.

Bar Vibrator Machine

This unit is decreasing in popularity because it is not adaptable for use with the slipform paver. It is similar in design to the mesh depressor of the Heltzel Co., except that notches are used under the grid to hold the steel bars in their proper position.

Two Illinois contractors, working in 1964, used two machines to place reinforcing bars by a method which eliminated chair supports and permitted single lift paving. The first machine was a riding platform, 45 ft in length, which traveled behind a concrete spreader. (See Fig. 4) This unit was manned by workers who took bundles of 30 ft long bars from delivery cranes and strung them out in position, spliced and wire-

tied them, and fed the bar lines into a set of spacing cups. The steel drew itself off as the rig advanced. Transverse bars were placed on 25 inch centers by two reels mounted in front of the machine. These transverse bars were positioned on the longitudinal bars.

The second machine, which performed the actual depressing of the steel, consisted of two 12 x 15 foot assemblies of large vibrating grids. (See Fig. 5) After the machine was moved into position over the slab, a hydraulic ram depressed the bars for 15 ft length of slab. Grooved surfaces distribute the ram pressure over the steel and insured its even submergence without local distortion or major disturbance of the fresh concrete.

Tube Assembly

This machine holds the reinforcement in position while the concrete is deposited, spread and consolidated. It consists of a form riding frame which contains flared tubes for receiving and positioning the steel just ahead of the concrete spreader. Two modifications of this machine are currently in use. The first of these, 44 or 48 lines of reinforcement are fed through tubes. (See Fig. 6) In the second version, the middle 6 bars are not positioned but instead are supported with tie bars on chairs. (See Fig. 7) The first type has recessed tubes, whereas the second type has all tubes of equal length.

The first step in the paving operation is to lay the steel reinforcement out on the subgrade, lapped and tied. The steel is then fed individually through flared tubes which are 16 to 30 ft in length and are 44 or 48 in number, depending on the design spacing of longitudinal

bars. The outside diameter of the flares is about 3 inches and the inside diameter of the tubes is 2 1/2 inches. After bar feeding, the unit is attached to the front of the concrete placer where it is held at the proper elevation while the concrete is placed and consolidated. (See Fig. 8) The height of the tubes can be adjusted with the aid of double nuts and bolts which are located in the top of the attaching beam in the rear: another set of double nuts at the bottom can be used to adjust the tubes horizontally. The unit itself is controlled from the operator's console. One version now in use has hydraulic cylinders at each corner to control the height. The frame holding the tubes is hinged on the bottom at the center line of the roadway with a hydraulic cylinder on top of this hinged portion. This center cylinder will raise the tubes to the desired straight-line crown. Tie bars, depending on their position, can be inserted by hand or by rotating notch drum at the back of the placer. They can also be supported on chairs.

Rebar Installer

This machine was introduced by the Rex Chainbelt Co. in 1969. It was designed to be compatible with Rex's belt placer although it can be used with slipform paver. It consists of four drums on each of which is mounted a set of helical rows of teeth like those on a mower sickle bar. These drums span the entire width of the slab and are mechanically operated. They are designed to slowly rotate while the individual bars are gradually tamped downward to the desired position.

The drums operate independently of each other, and are hydraulically controlled from the slipform console.

The paving operation is started by laying, lapping, and tieing continuous lengths of reinforcing rods on the subgrade. There is no need to line up these rods accurately. The steel is then raised above the subgrade by a roller in front of the spreader, and is threaded to the belt placer in two separate sets. (See Fig. 9) The steel goes over the belt spreader and out through the back. A rubber tired unit attached to the trailing forms of the spreader brings the two sets of steel together and roughly spaces them across the width of the pavement. This unit has two horizontal pipes between which is a series of short vertical rollers, placed either at 6 or 6 1/2 inches depending on the number of lines of steel bars (usually 40 or 48 lines). The rods are fed through these rollers for proper spacing. (See Fig. 10)

Another spacing unit is attached to the slipform paver, and is similar in design to the other spacer. Here all the bars are properly spaced and held in position by the set of vertical rollers. This unit is followed by the track-mounted, saw-toothed rotary tampers which are attached to the front of the slipform paver. As the machine advances, the drums revolve and the serrations slip over the rods and force them down into the fresh concrete. (See Fig. 11) Since the rebar installer is attached to a slipform paver and takes its grade from the paver wires, it installs the steel precisely to the desired elevation. (See Fig. 12)

SUMMARY OF FINDINGS

The extent of use of mechanical steel placers in this country was evaluated through questionnaires directed to selected highway officials, correspondence and interviews with contractors and other highway officials, and observations of actual jobs. The procedures followed on selected jobs were recorded on film with the aid of a time lapse camera, and the pictures were later used in analyses of the placement methods and techniques. From the observation and the subsequent analyses the following conclusions were derived:

1. The number of states which has turned to the use of CRC pavements is rapidly increasing.
2. Machines are now available which can place steel faster, at less expense and with less labor than the manual operations formerly employed. These machines have been used to the general satisfaction of the state highway officials.
3. Several states have modified their specifications so as to accommodate placement tolerances which are compatible with these mechanical methods.
4. Many states have eliminated the use of transverse bars in the construction of their CRC pavements.
5. Through adequate planning, and through the use of mechanical methods for steel placement, contractors have demonstrated that they can improve the efficiency of their steel laying operations.

6. The presently available mechanical devices for depressing steel are not yet fully perfected, but additional improvements can be expected in the future.
7. The savings which can currently be realized from the use of mechanical steel placers cannot be specifically identified because of the limited experiences of contractors with their use. However, the potential savings can be sufficiently attractive to warrant the interest of highway officials.

FIGURE 1

lieltzel Flexplane mesh and rod depressor in operation on 24 ft. wide slab

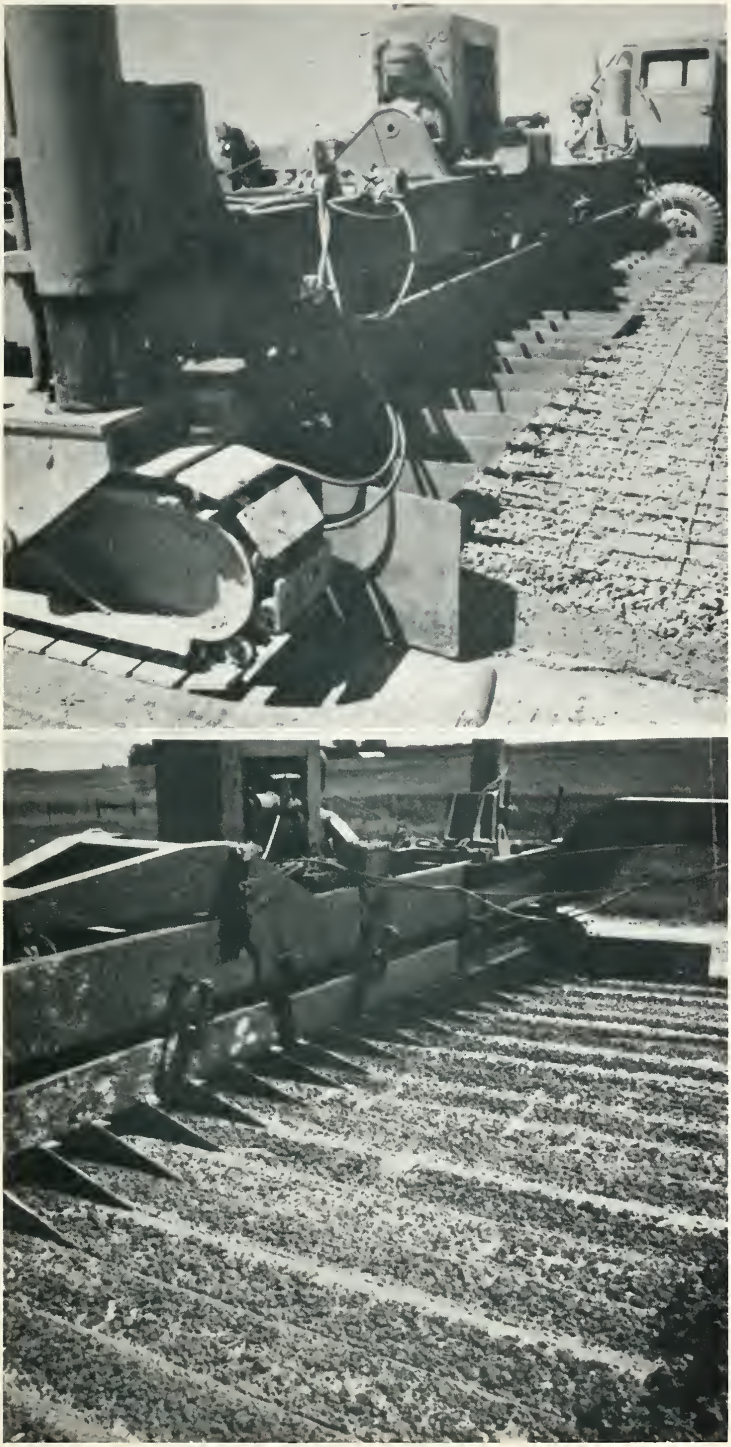

FIGURE 2

Front and Rear Views of a Rex Mesh Depressor

FIGURE 3

Front and Rear Views of a CMI Mesh Depressor

FIGURE 4
Jumbo Satellite Machine
Helps Speed Steel Lapping and Tieing Operation

Figure 5

Bar Vibrator Machine
(Notice the similarity to Figure 36)

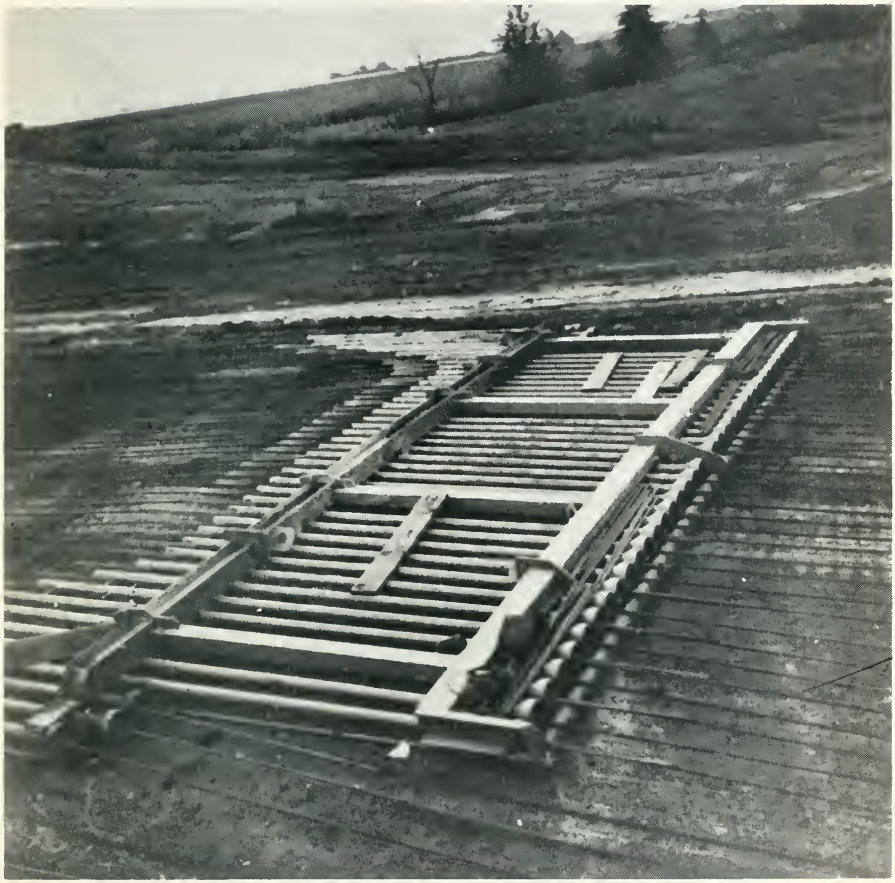

Figure 6

First Type of Tube Assembly

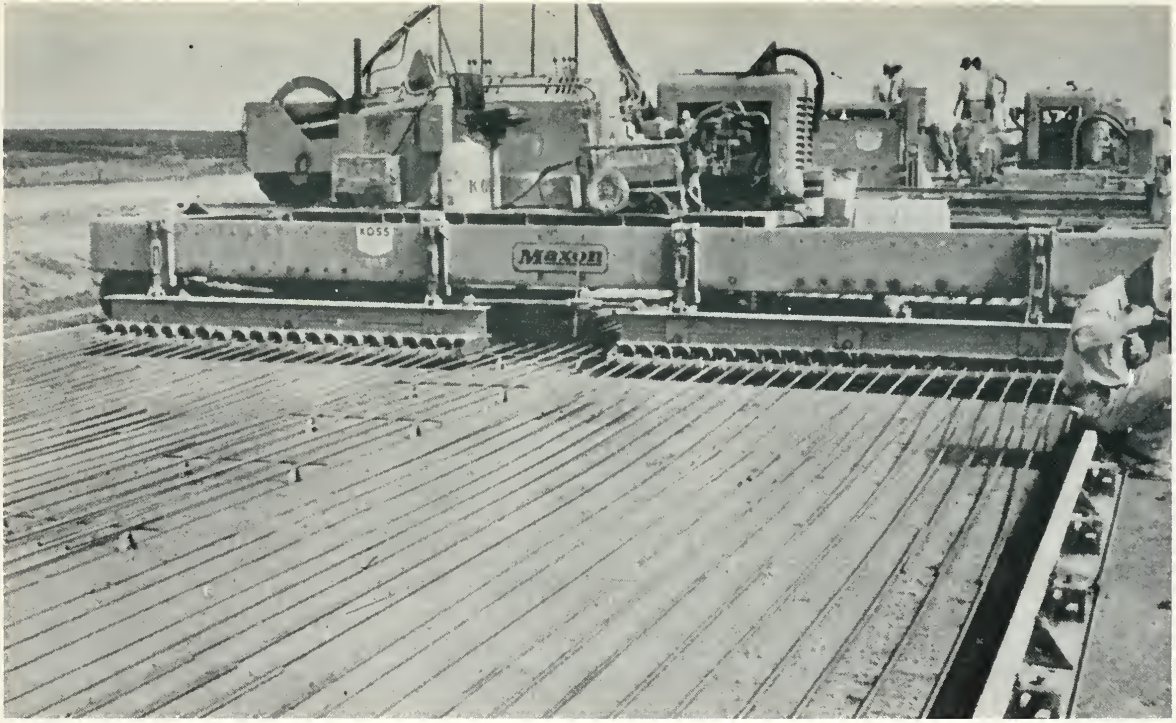

Figure 7

Second Type of Tube Assembly

(Notice that the middle 6 bars are supported on chairs)

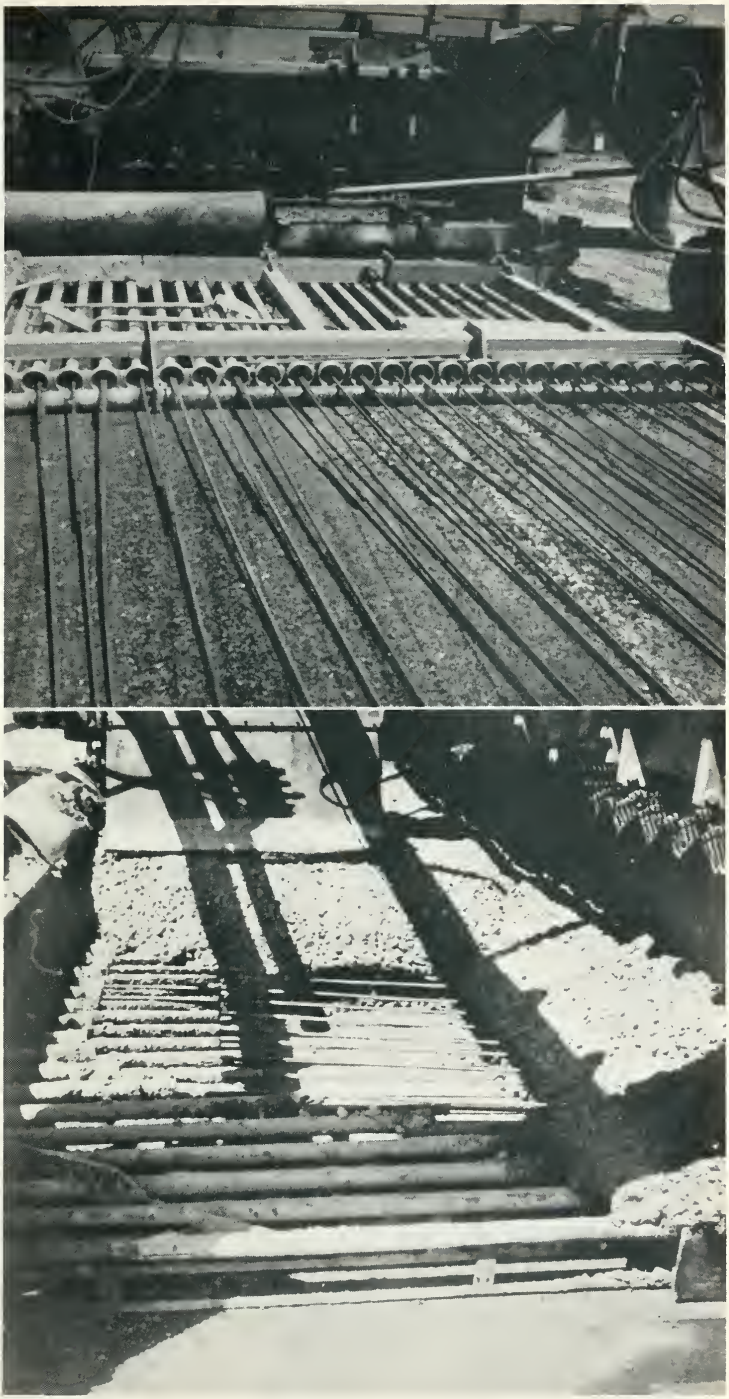

Figure 8

Tube Assembly Holds the Steel in Place
as the Concrete is Placed, Spread and Consolidated

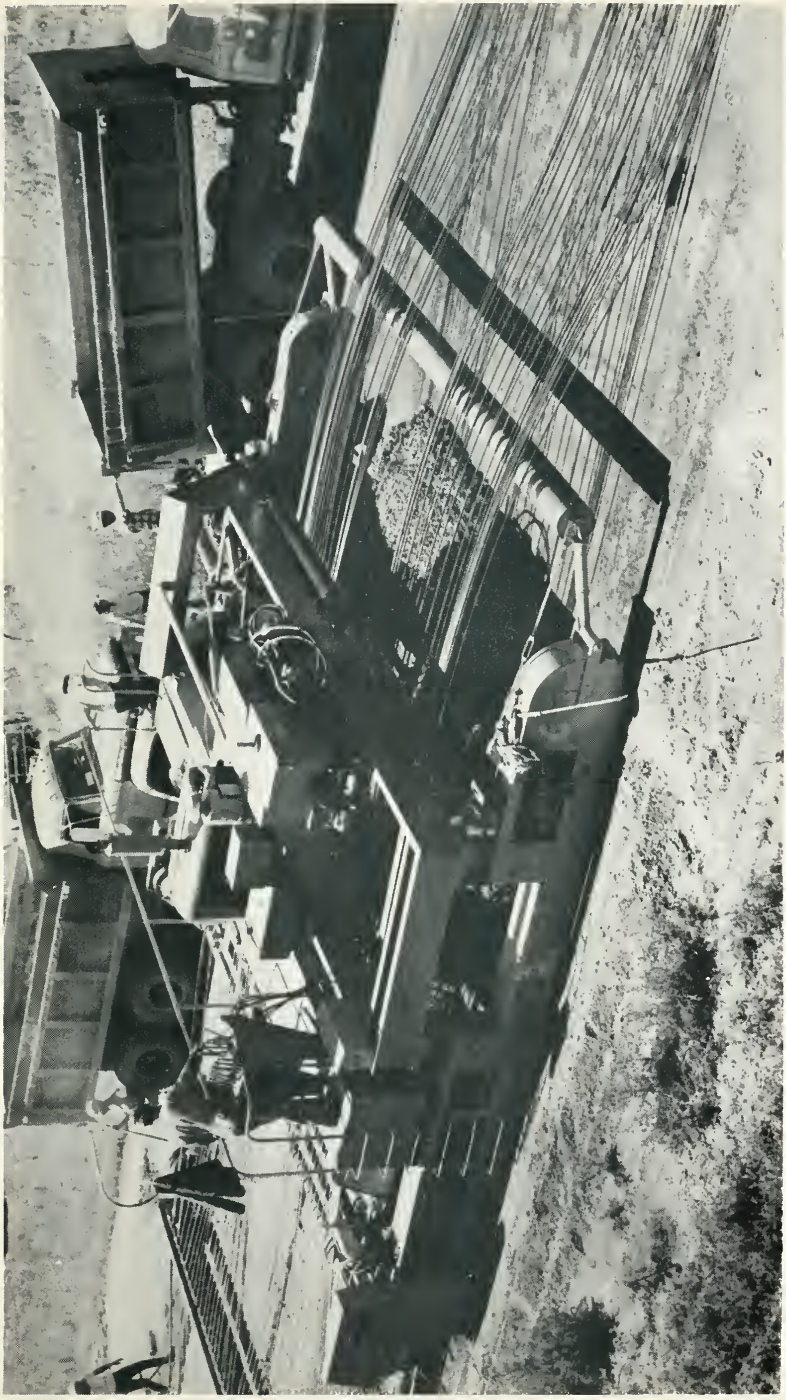

Figure 9

A Roller Raises the Steel Above the Subgrade

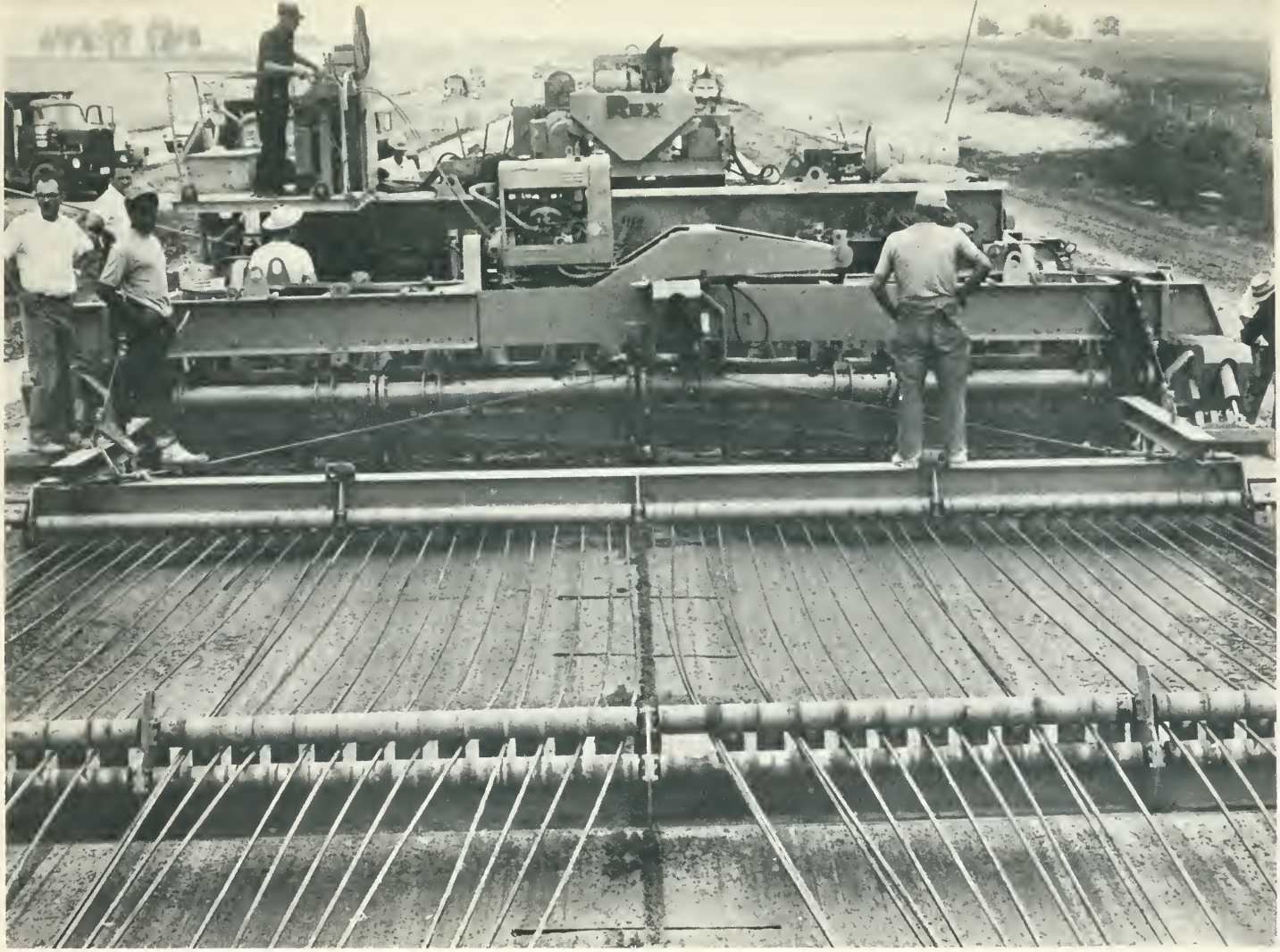

Figure 10

A Bar Spacer Attached to the Placer Roughly Spaces the Bars

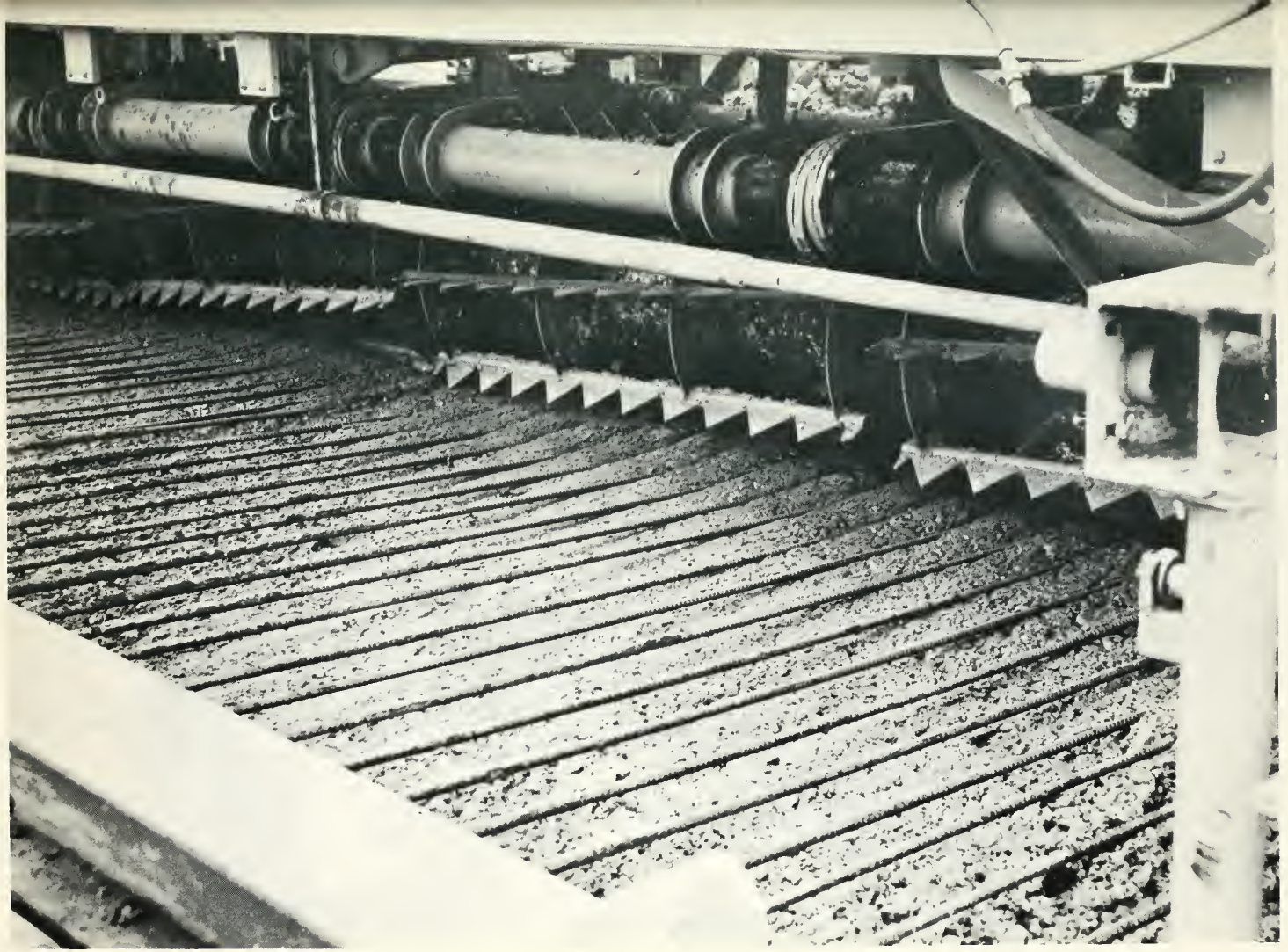

Figure 11

The Serrated Device Tamps and Depresses the Steel to Position

Figure 12

The Complete Paving Train